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C-130 WELDBONDED FUSELAGE PANEL FLIGHT EVALUATION PROGRAM.(U)

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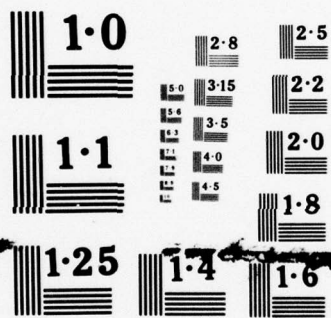
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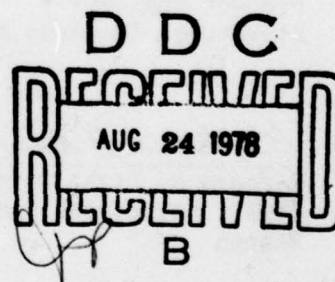
C-130 WELDBONDED FUSELAGE PANEL FLIGHT EVALUATION PROGRAM

J. A. KIZER

LOCKHEED-GEORGIA COMPANY
MARIETTA, GEORGIA 30063

DECEMBER 1977

FINAL REPORT OCTOBER 1974-DECEMBER 1977



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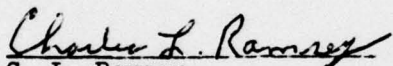
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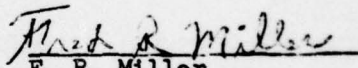
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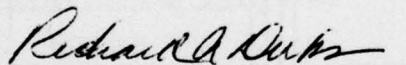
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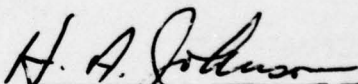
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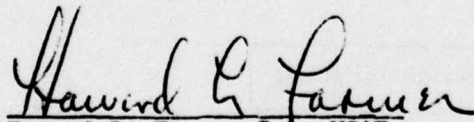

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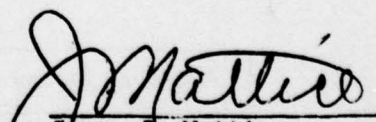

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The objective of this program was to conduct an in-service evaluation of the C-130 weldbonded fuselage panel. The evaluation period extended over a three year span beginning with delivery of the C-130 aircraft in late October, 1974. A total of seven nondestructive inspections were conducted during which all of the inspections included visual and ultrasonic inspection of the weldbonded joints. Three of the seven inspections included radiographic inspections of a portion of the spot-welds in the weldbonded fuselage panel. All inspections		

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At the time of the seventh inspection, October, 1977, the C-130 aircraft on which the weldbonded fuselage panel is installed had accumulated a total of 2296 flight hours.

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FOREWORD

This Final Technical Report was prepared by Lockheed-Georgia Company, a Division of Lockheed Corporation, Marietta, Georgia, under contract No. F33615-75-C-3010, entitled "C-130 Weldbonded Fuselage Panel Flight Evaluation Program". The report presents results of the contract during the period from October 1974 through December 1977. The contract work consisted of inspecting the weldbonded fuselage panel installed on operational C-130 aircraft, Serial No. AF73-01592, co-incident with aircraft isochronal inspections. A total of seven inspections were performed during which all of the inspections included visual and ultrasonic inspection of the weldbonded joints. Three of the seven inspections included radiographic inspection of a portion of the spot-welds in the weldbonded fuselage panel.

Mr. C. L. Ramsey (AFFDL/FBS) was the Air Force Flight Dynamics Laboratory Project Manager. M/Sgt. T. L. Dugger (LGMC/314th TAW), Little Rock Air Force Base, was the C-130 Maintenance Control Office Coordinator. Mr. E. R. Tanner was the 314th TAW FMS/NDI Laboratory Coordinator. All Little Rock Air Force Base personnel ably assisted the Lockheed inspection teams in scheduling the inspections, arranging for aircraft hangar space having necessary electrical outlets, preparation of the weldbonded fuselage panel for inspection, and making the Nondestructive Inspection Laboratory facilities including some inspection equipment available in conducting the inspections.

Mr. J. A. Kizer was the Lockheed-Georgia Company Program Manager. Major contributions in accomplishing the inspections were provided by Messrs. D. H. Dysart, W. P. Lanier, R. J. Smith, W. H. Thompson, and H. H. Woods of the Proficiency Development Laboratory in the Quality Assurance Branch of the Lockheed-Georgia Company.

The Lockheed-Georgia Company report identification for this AFFDL/AFML Document is LG77ERO218.

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SUMMARY

Periodic visual, ultrasonic and radiographic inspections were accomplished on the weldbonded fuselage panel installed on C-130 aircraft, Serial No. AF73-01592. This fuselage panel was designed, fabricated and installed on the C-130 aircraft under Air Force Contract F33615-71-C-1716. Since delivery of the aircraft in October, 1974, the weldbonded fuselage panel was inspected concurrent with seven periodic aircraft inspections. During all seven inspections, the adhesive bondlines in the weldbonded joints were ultrasonically inspected and the surface finishes were visually inspected with a pocket magnifier (approximately 7X). Also, during three of the seven inspections, the spot-welds in the aftermost region of the weldbonded fuselage panel were radiographically inspected. Radiographic and ultrasonic procedures developed under Contract F33615-71-C-1716 were utilized in conducting the inspections. All inspections were conducted at the Little Rock Air Force Base where the C-130 aircraft having the weldbonded fuselage panel is assigned to the 314th Tactical Airlift Wing. Since delivery of the C-130 aircraft, the weldbonded fuselage panel has performed with a minimum of problems. The only minor problem that arose was some small breaks in the interior paint finish that were detected during the fifth inspection. These small breaks occurred in the paint finish over the frame-to-cover skin joint fillets and were detected with the aid of a seven-power pocket magnifier

as they could not have been detected by the naked eye. Air Force maintenance personnel repaired the small finish breaks and no finish breaks were detected in the subsequent inspections of the fuselage panel.

In the early phase of the contract, a spare production fuselage panel was procured and stored at the Lockheed-Georgia Company for replacement of the weldbonded fuselage panel if for any reason it was necessary. As the weldbonded panel performed with nearly trouble free service, the spare production fuselage panel was shipped to Wright-Patterson Air Force Base as required by the contract.

SECTION I

INTRODUCTION AND BACKGROUND

This flight evaluation program was conducted on the weldbonded fuselage panel installed in C-130 aircraft, Serial No. AF73-01592. The fuselage panel was designed, fabricated and installed under an Air Force sponsored program¹. The location of the weldbonded fuselage is shown in Figure 1. As shown in Figure 1, the forward left-hand weldbonded fuselage panel, Dwg. No. 3307701, extends from Fuselage Station 280.33 to Fuselage Station 337.0. The height of the weldbonded fuselage panel is 117 inches with the upper end attached at the main cargo floor. The periphery of the weldbonded panel is attached to adjoining fuselage structure by standard riveted splices. Also, the splice at Fuselage Station 337.0 is a riveted splice. There are weldbonded joints at fifteen (15) fuselage stations, cargo tie-down support structure, intercostals, and reinforcement doubler plate. The weldbonded joints and the mechanical splice at Fuselage Station 337.0 are shown in Figure 2. All weldbonded joints were fillet sealed with the corrosion inhibiting sealant, MIL-S-81733. The exterior surface of the weldbonded fuselage panel is finished identically to the other exterior surfaces of the aircraft. The interior surface of the weldbonded fuselage panel has two different finish systems. The forward section of the panel extending from Fuselage Station 280.33 to 337.0 is finished with a one mil coat of PR-1432GP inhibited primer followed by a one mil coat of MIL-C-83019 clear flexible polyurethane. The aft section of the

¹Grosko, J. J. and Kizer, J. A., "Weldbond Flight Component Design/Manufacturing Program," AFML-TR-74-179/AFFDL-TR-106, December, 1974

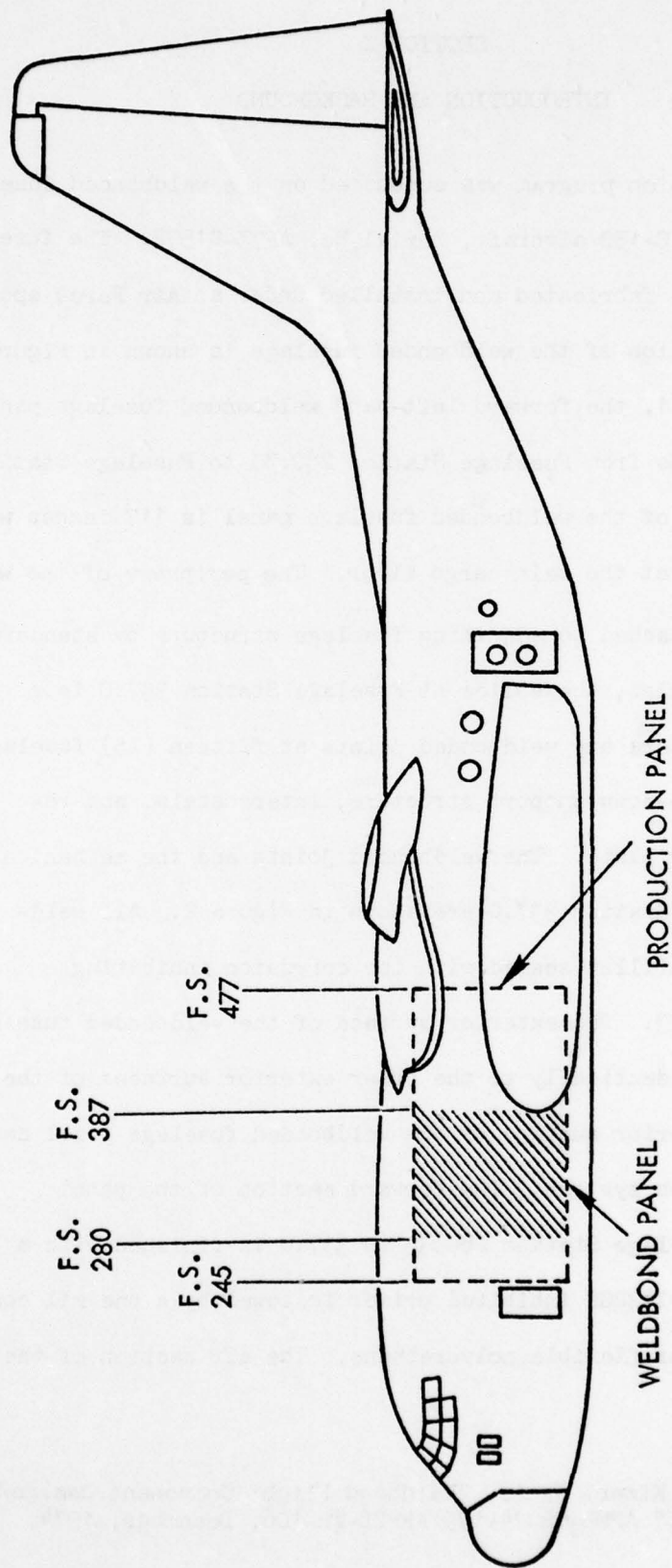


Figure 1 - Weldbonded Panel Installed in Forward Left
Side of C-130 Fuselage

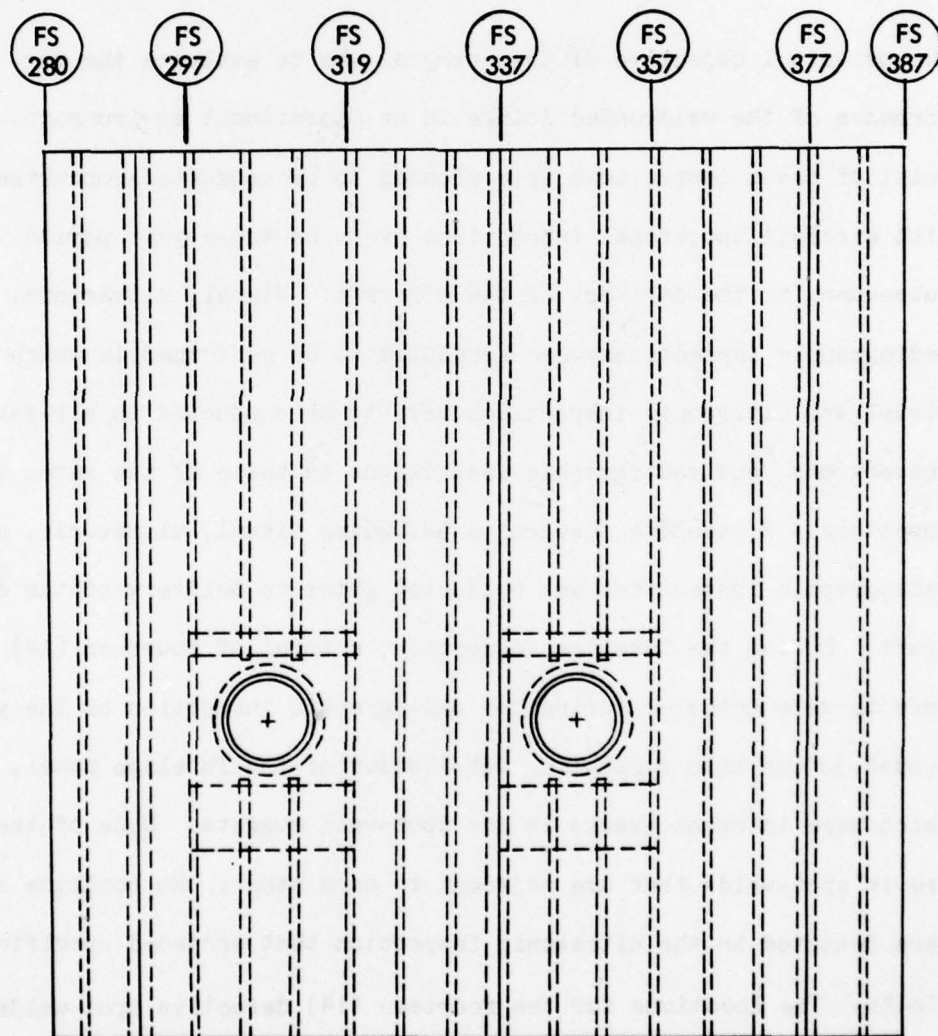
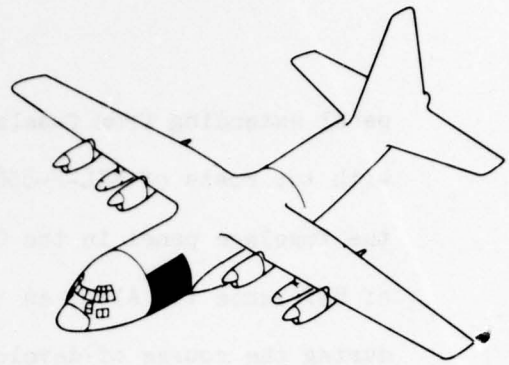
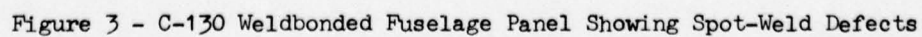


Figure 2 - Weldbonded Fuselage Panel

panel extending from fuselage station 337.0 to 387.0 is finished with two coats of MIL-P-8585 zinc chromate primer. Installation of the fuselage panel in the C-130 aircraft is described in Section XI of Reference 1. Also, an in-service monitoring plan was prepared during the course of development and it is included in Section XII of Reference 1.

The principal objective of this program was to evaluate the performance of the weldbonded joints in an operational environment. A total of seven inspections were planned to be conducted concurrently with aircraft isochronal inspections over the three-year period subsequent to the delivery of the aircraft. Visual, ultrasonic, and radiographic inspections were scheduled to be performed in which visual and ultrasonic inspections were to be conducted in all seven inspections, and radiographic inspections in three of the seven inspections. A baseline inspection including visual, ultrasonic, and radiographic inspections was conducted prior to delivery of the aircraft. During the baseline inspection, a total of fourteen (14) defects were detected during the radiographic inspection of the weldbonded joints upon completing fabrication of the fuselage panel, all of which were internal cracks in the spot-weld nuggets. None of the defects are in spot-welds that are adjacent to each other. No bondline defects were detected in the ultrasonic inspection that exceeded specification limits. The locations for the fourteen (14) defective spot-welds are shown on Figure 3.



SECTION II

PERIODIC INSPECTION PROCEDURES

The following inspection procedures were used in the C-130 weldbonded fuselage panel inspections conducted under this contract. They are also recommended to be used in future inspections. These procedures encompass visual, ultrasonic, and radiographic inspections of the weldbonded joints.

Prior to conducting each inspection, the following items are to be accomplished.

- 1) Locate the C-130 aircraft in an area in which 110-115 volt, 60-cycle electrical power is available for operating the contact ultrasonic and radiographic equipment. All electrical power in the aircraft is to be turned off except those circuits required to illuminate the interior fuselage cabin in the vicinity of the weldbonded panel installation.
- 2) The exterior surface of the weldbonded fuselage panel is to be washed to thoroughly clean the surface of all foreign materials, such as dirt or grit, which may prevent intimate contact between the ultrasonic transducer and the surface of the panel.

Standard detergents mixed in water solutions for washing the exterior surfaces of the C-130 airplane may be used to clean the exterior surface of the weldbonded fuselage panel.
- 3) The insulation blankets and troop seat harnesses must be removed in the area of the weldbonded fuselage panel to make the interior

3) Cont'd

surface of the panel including joints and splice fillets accessible for inspection.

- 4) It is advisable to conduct radiographic inspections at night in order to reduce possible radiographic exposure to the least number of personnel in the area. All radiographic inspections conducted in this program were accomplished during the evening shift. During nondestructive inspections of the airplane, referral for safety precautions is made to Section I of Technical Order 1C-130A-36 and Technical Order 33B-1-1.

2.1 Visual Inspections

Visual inspections are to be made over 100 percent of the exterior and interior surfaces of the weldbonded fuselage panel including all joints, splices, fuselage skins, reinforcing doublers and cargo tie-down brackets. Both interior and exterior surfaces of the weldbonded panel are to be inspected for cracks in the finish systems and for evidence of corrosion. The interior surface is to be inspected with the aid of a Bausch & Lomb pocket magnifier (approximately 7X) or equivalent.

2.2 Contact Ultrasonic Inspections

Contact ultrasonic inspections are to be conducted using the following procedures and equipment.

A. Ultrasonic Equipment:

- (1) Reflectoscope, Sperry P/N UM-715 or equivalent.
- (2) Transducer, 5.0 MHz 0.250 inch diameter Type SFZ or equivalent.
- (3) Acoustic Couplant, tap water mixed with wetting agent
- (4) Transducer Cable, 12-foot length, Microdot/UHF connector or equivalent.
- (5) Calibration Standard, as illustrated in Figure 4.

B. Instrument Calibration/Settings: Calibration of the UM715 Reflectoscope or equivalent may be accomplished for either painted or unpainted, single and double bondlines using the appropriate portion of the standard shown in Figure 4.

- (1) Apply couplant on the designated Area 2 of the standard.
- (2) Place the transducer on a known good quality section of Area 2.
- (3) Adjust the Reflectoscope sweep to obtain a signal occupying approximately 50 percent of the cathode ray tube (CRT) screen. The signal of a quality bondline is as shown on Figure 5.
- (4) Place the transducer over known nearside and farside disbands in the appropriate zones of Area 2 of the standard.
- (5) Adjust the sweep delay/length controls of the Reflectoscope to move all signals off the CRT screen. A representative signal of both types of disbands is shown on Figure 6.

NOTE:

- ① .50 HOLE DRILLED TO ALUMINUM
- ② .50 HOLE DRILLED TO ADHESIVE
- ③ PAINT ZONE 1 - FUS. STA. 280-337
- ④ PAINT ZONE 2 - FUS. STA. 337-387
- ⑤ UNPAINTED ZONE FOR COMPARATIVE PURPOSES AND USE AS NEARSIDE DISBOND BACK-UP
- ⑥ M6800 PASTE ADHESIVE
- ⑦ MYLAR/SCRIM INSERT FOR HOLES DRILLED TO ALUMINUM ONLY

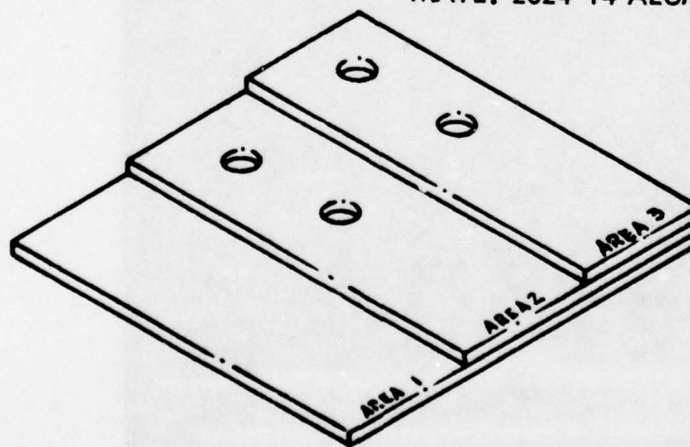
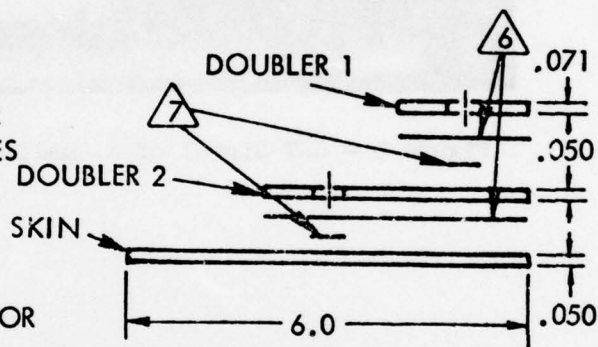
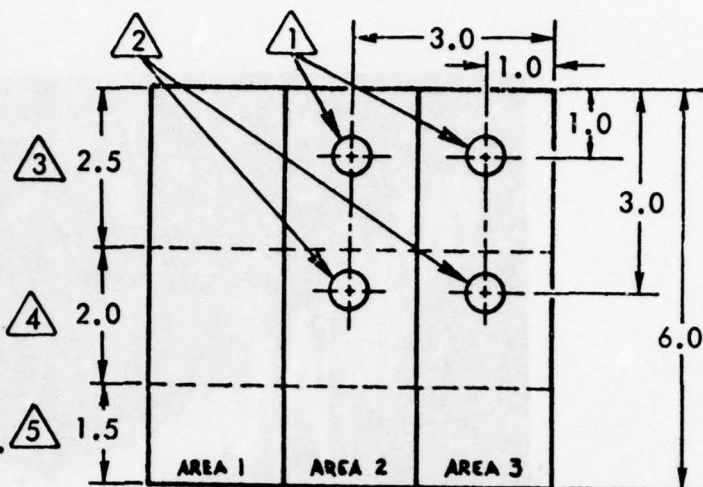


Figure 4 - Calibration Standard for In-Service Inspection of C-130 Weldbonded Fuselage Panel

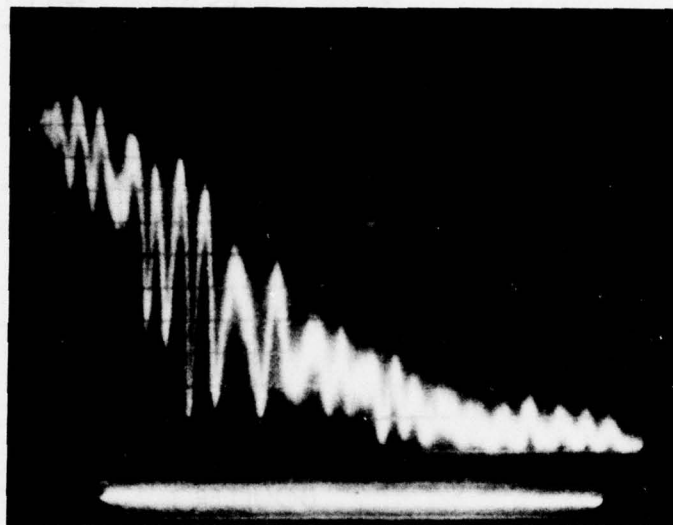


Figure 5 - CRT Signal of a Quality Bondline

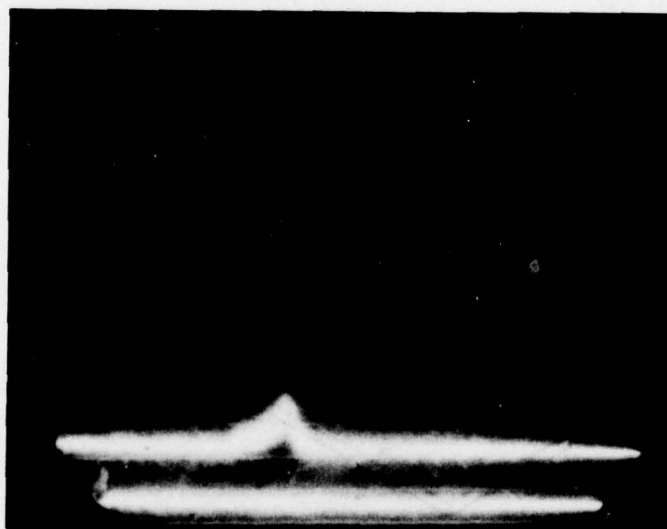


Figure 6 - CRT Signal of all Types of Disbonds in Bondline

B. Instrument Calibration/Settings: Cont'd

NOTE

Attenuation by sealant, paint finishes, material differences, etc., may cause a difference in sensitivity between the standard and assembly being inspected. This difference shall be determined and compensated for prior to inspection.

- (6) In double bondlines, calibration for the nearer bondline is accomplished using Area 2 of the standard. The calibration for the second bondline in double bondline joints is accomplished using Area 3 of the standard in a manner similar to that described above.

C. Inspection: After the surfaces of the weldbonded fuselage component have been cleaned, the calibrated ultrasonic inspection equipment is used to inspect the bondlines in the weldbonded joints as follows:

- (1) Apply couplant to the exterior surface of the weldbonded joint which corresponds with the calibration area on the CRT screen.
- (2) Scan the entire bonded area of the weldbonded joint, with the exception of spot-welds, slowly moving the transducer over the bonded area carefully noting the signal on the CRT screen.
- (3) Identify and record all suspected defects whose area is in excess of 0.16 square inches.

NOTE

If a suspected defect is detected that is in excess of 0.16 square inch in area, typical repair procedures² are contained in the aircraft logs. It is further noted that the fuselage skin between Fuselage Stations 280.33 and 337.0 may not produce a ringing signal in areas outside the weldbonded joints due to the inhibited primer plus clear polyurethane finish on the interior surface and, therefore, cannot be used as a calibration check for voids or disbonds in the bondlines.

2.3 Radiographic Inspections

Radiographic inspections are to be conducted using the following procedures and equipment.

A. NDI Equipment:

(1) X-ray Machine, Portable, 40-Degree Tube Head, Magnaflux-Model M-X-150KV or equivalent.

(2) X-ray film, Kodak Type M or equivalent

B. Preparation of weldbonded panel: No special preparation required.

C. X-ray machine settings: Set X-ray machine for radiographic inspection of the spot-welds in the weldbonded joints in accordance with settings in Table 1.

²"In-Service Monitoring Plan for the C-130 Weldbonded Fuselage Side Panel (Revision 1)," Service Manual Publication No. 895, Lockheed-Georgia Company, 1974

TABLE 1 - RADIOGRAPHIC INSPECTION DATA

EXPOSURE NUMBER	KV	MA	FFD (inches)	TIME (Sec)	FILM		REMARKS
					TYPE	SIZE	
Area 1	65	5	72	90	M	4.5x17	Applicable to all areas outside of ice shield
Area 2	65	5	72	120	M	4.5x17	Applicable to area beneath ice shield

NOTE: Slight adjustments may be necessary on several of the parameters in the above table to account for variations in equipment.

SECTION III

PERIODIC INSPECTIONS OF THE WELDBONDED

FUSELAGE PANEL

The C-130 weldbonded fuselage panel was periodically inspected over the period from October, 1974 to October, 1977. The C-130 aircraft having the weldbonded fuselage panel was assigned to the 314th Tactical Airlift Wing (TAW) based at Little Rock Air Base, Arkansas, and all seven (7) inspections were conducted at that base. A schedule of the seven inspections that were accomplished is presented in Table 2. Also, this table shows the types of inspections that were conducted. Prior to beginning each inspection, the 314th TAW personnel washed the exterior surface of the weldbonded fuselage panel in readying it for inspection by the Lockheed inspection team. Also, they removed the insulation blankets and troop seat harnesses over the area of the weldbonded fuselage panel to provide accessibility for visual inspection of weldbonded joints and splices. After completion of each inspection, 314th TAW personnel reinstalled the insulation blankets and troop seat harnesses.

The weldbonded fuselage panel was ultrasonically and visually inspected at each of the seven inspections applying the applicable procedures described in Section II. The adhesive bondlines in the weldbonded joints were contact ultrasonically inspected by carefully scanning the exterior surfaces of the joints with the flaw detector transducer noting the display on the flaw detector screen. All of the weldbonded joint bondlines were ultrasonically inspected except those

TABLE 2 - C-130 WELDBONDED FUSELAGE PANEL INSPECTIONS

INSPECT. NO.	INSPECTION DATE	INSPECTIONS CONDUCTED	FLIGHT HOURS ACCUM.	INSPECTION RESULTS FROM FIELD INSPECTIONS*
1	Jan. 9, 1975	Visual and Ultrasonic	162	No adhesive bond defects were detected that exceeded specification limits. No breaks in the surface finish were detected.
2	June 17, 1975	Visual and Ultrasonic	551	No adhesive bond defects were detected that exceeded specification limits. No breaks in the surface finish were detected.
3	Oct. 16, 1975	Radiographic, Visual and Ultrasonic	826	No adhesive bond and spot-weld defects were detected that exceeded specification limits. No breaks in the surface finish were detected.
4	Mar. 24, 1976	Visual and Ultrasonic	1120	No adhesive bond defects were detected that exceeded specification limits. No breaks in the surface finish were detected.
5	Oct. 23, 1976	Radiographic, Visual and Ultrasonic	1581	No adhesive bond and spot-weld defects detected that exceeded specification limits. Fourteen (14) small breaks detected in surface finish.
6	Apr. 5, 1977	Visual and Ultrasonic	1924	No adhesive bond defects were detected that exceeded specification limits. No breaks in the surface finish were detected.
7	Oct. 20, 1977	Radiographic, Visual and Ultrasonic	2296	No adhesive bond and spot-weld defects were detected that exceeded specification limits. No breaks in the surface finish were detected.

*No growth was detected in any of the fourteen (14) spot-weld defects detected in the baseline inspection which exceeded specification limits.

beneath the ice protection shield which are inaccessible. Contact ultrasonic techniques applied in accomplishing all field inspections were identical to those used in the baseline inspection conducted immediately before the delivery of the C-130 aircraft. The Magnaflux PS702 Flaw Detector or the UM-715 Reflectoscope with a 5 MHZ 0.250-inch diameter transducer was calibrated with the aid of a calibration standard as shown in Figure 4 prior to each ultrasonic inspection. After calibrating the ultrasonic inspection equipment and wetting the exterior surface areas of the weldbonded joints with an acoustic couplant, the bondlines were scanned for voids and disbonds that exceed the specification limits. The specification limits are published in Reference 1 and are as follows:

- (a) The maximum void in the bondline shall not have an area greater than 0.16 square inch.
- (b) The maximum aggregate void content between any two adjacent spot-weld nuggets shall be 0.16 square inch.
- (c) The maximum permissible void or disbond area within an assembly shall not exceed 5 percent of the total bonded area within the assembly.
- (d) No voids shall be within 0.13 inch of any edge.

The seven (7) field ultrasonic inspections plus the baseline ultrasonic inspection did not determine any defects that exceeded the specification limits given above.

Both exterior and interior surfaces of the weldbonded fuselage panel were visually inspected. The weldbonded joint and splice fillets were

visually inspected with the aid of a Bausch and Lomb pocket magnifier (approximately 7X). The only breaks in the finish system were detected during the fifth inspection. A total of fourteen (14) small breaks were detected in the interior panel surface finish which occurred in the paint finish over the frame-to-cover skin joint fillets. All of these small breaks were detected with the aid of the pocket magnifier as they could not have been detected by the naked eye. Air Force maintenance personnel repaired the small finish breaks and no finish breaks were detected in the subsequent two inspections.

Radiographic inspections of the spot-welds in the aftermost region of the weldbonded fuselage panel were conducted during the third, fifth and seventh inspections. The spot-welds in the weldbonded splice at fuselage station 377.0 and the Z-section ring frame-to-skin joints at fuselage stations 357.0, 363.67, 370.33, and 383.67 were radiographically inspected during each of the three inspections. In addition, the fourteen (14) spot-welds detected during the baseline inspection that had internal cracks that exceeded specification limits were radiographically inspected during each of the three inspections for possible propagations. Radiographic inspection procedures and equipment used in conducting each of the three radiographic inspections were those described in Section II. During the three radiographic inspections, no additional spot-weld defects were detected and no propagations were revealed in any of the fourteen (14) spot-weld defects detected in the baseline inspection.

At the time of the seventh inspection of the weldbonded fuselage panel, the C-130 aircraft had accumulated a total of 2296 flight hours. The

aircraft is continuing to be used in basic and proficiency training as well as cargo missions.

SECTION IV

PROCUREMENT, STORAGE AND SHIPMENT OF SPARE

PRODUCTION FUSELAGE PANEL

A spare standard, undrilled C-130 forward fuselage panel, Dwg. No 388005-29, was procured and stored for replacement of the weldbonded fuselage panel if for any reason it became necessary. This spare standard fuselage panel was procured from the fabricator, Scottish Aviation Company, Ltd., from which all of the other production fuselage panels are procured for C-130 airplanes. The spare standard fuselage was delivered to the Lockheed-Georgia Company, Marietta, Georgia, in May , 1975. It was packed in a **specially-fabricated** wooden shipping crate for shipment of the panel by water and overland transportation. The interior surfaces of the shipping crate are lined with a waterproof, flexible caseliner barrier material to prevent moisture and humidity from coming in contact with the fuselage panel. The shipping crate contains several thick, contoured wooden members that support the panel during shipment and storage. Thick felt padding is attached to the contoured wooden members on which the fuselage panel rests during shipment and storage. This padding protects the panel surface from abrasions to the finish and prevents damage from vibration shocks. Reinforcing 2-inch by 4-inch wooden stiffening members are attached to all exterior edges of the shipping crate plywood panels to form a stiff, rugged container for transporting the fuselage panel. For hoisting purposes, two pairs of flat steel bars having swivel-type pick-up rings on one end of each bar are bolted

to the shipping crate. All joints of the shipping crate are sealed to prevent attack on the fuselage panel by hostile environments.

Upon delivery of the spare standard fuselage at the Lockheed-Georgia Company, it was stored in its shipping crate on the main floor of the production assembly building. The exterior surfaces of the wooden shipping container were inspected upon its arrival as the fuselage panel was not removed from the shipping container.

A recommendation for disposition of the spare standard fuselage panel was submitted in September, 1977, in accordance with contract requirements. The weldbonded fuselage panel has performed with a minimum of problems over the three-year period that it has been in operational service. As the result, it is anticipated that the weldbonded fuselage panel will not require replacement in the foreseeable future.

Accordingly, it was recommended that the fuselage panel be shipped to an Air Force base for storage and possible subsequent usage in the event of accidental damage to an in-service aircraft. It is noted that the spare standard fuselage panel is not of the same configuration as those currently used in the C-130 production program and thus cannot be used as a production asset. Thus, the crated spare standard panel was shipped to AFFDL of the Wright-Patterson Air Force Base in October, 1977, where it is stored.

SECTION V

CONCLUSIONS AND RECOMMENDATIONS

The C-130 weldbonded fuselage panel has performed with a minimum of problems over the three-year period subsequent to delivery of the aircraft. During the experience of being in an operational environment, the weldbonded fuselage panel has not received any special treatment. The C-130 aircraft on which the weldbonded panel is installed has been and is continuing to be used in basic and proficiency training as well as performing cargo missions. In addition, the aircraft has received foreign rotational assignments similar to other aircraft in the user command. Thus, it is concluded that the weldbonded joints have satisfied the operational requirements up to the time of release of this final report and it is anticipated that it will not require replacement in the foreseeable future.

It is recommended that the weldbonded fuselage panel inspections be continued upon completion of this program, although the inspections need not be as frequent as in this program.

This recommendation is based on the satisfactory performance of the weldbonded fuselage panel since it entered operational service. Specifically, it is recommended that the spot-welds in the aftermost section of the weldbonded fuselage panel be radiographically inspected coincident with each aircraft depot maintenance (PDM) inspection. Furthermore, it is recommended that visual and ultrasonic inspections be conducted at every other aircraft isochronal inspection for the period between the first and second PDM. After the second PDM, visual and

ultrasonic inspections are recommended to be conducted at every third aircraft isochronal inspection provided the weldbonded fuselage panel continues to perform satisfactorily.